GRADE 12 DIPLOMA EXAMINATION

Physics 30

June 1988

Alberta
EDUCATION

GRADE 12 DIPLOMA EXAMINATION
PHYSICS 30

DESCRIPTION

Time: 2½ hours

Total possible marks: 70

This is a **CLOSED-BOOK** examination consisting of two parts:

PART A: 56 multiple-choice questions each with a value of 1 mark.

PART B: Three written-response questions for a total of 14 marks.

A physics data booklet is provided for your reference. Approved calculators may be used.

GENERAL INSTRUCTIONS

Fill in the information on the answer sheet as directed by the examiner.

For multiple-choice questions, read each carefully and decide which of the choices BEST completes the statement or answers the question. Locate that question number on the answer sheet and fill in the space that corresponds to your choice. **USE AN HB PENCIL ONLY.**

Example

This examination is for the subject area of

A. Chemistry
B. Biology
C. Physics
D. Mathematics

Answer Sheet

A	B	C	D
①	②	●	④

If you wish to change an answer, please erase your first mark completely.

For written-response questions, read each carefully, show all your calculations, and write your answer in the space provided in the examination booklet.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

DO NOT FOLD EITHER THE ANSWER SHEET OR THE EXAMINATION BOOKLET

The presiding examiner will collect the answer sheet and examination booklet for transmission to Alberta Education.

JUNE 1988

PART A

INSTRUCTIONS

There are 56 multiple-choice questions with a value of one mark each in this section of the examination. Use the separate answer sheet provided and follow the specific instructions given.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

WHEN YOU HAVE COMPLETED PART A, PROCEED DIRECTLY TO PART B

DO NOT TURN THE PAGE TO START THE EXAMINATION UNTIL TOLD TO DO SO BY THE PRESIDING EXAMINER

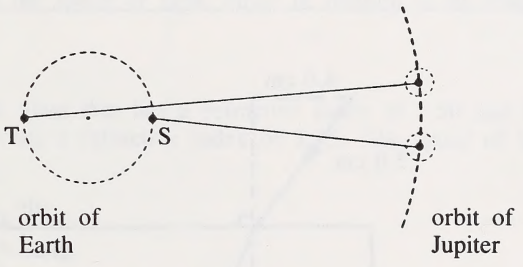
1. Blue light, with a wavelength in vacuum of 4.8×10^{-7} m, has a period of vibration of

A. 1.6×10^{-15} s
B. 6.9×10^{-3} s
C. 1.4×10^{2} s
D. 6.3×10^{14} s

2. Light travelling from one medium into another has an angle of incidence of 31.0° and an angle of refraction of 68.5°. If the index of refraction of the first medium is 1.86, then the index of refraction of the second medium would be

A. 1.81
B. 1.30
C. 1.03
D. 1.00

Use the following information to answer question 3.

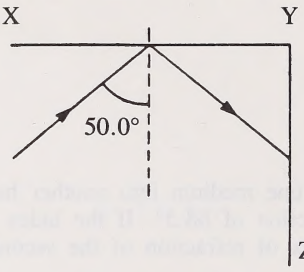


A group of amateur astronomers monitors the eclipse of one of Jupiter's moons over an extended period of time. From position S, the observed and calculated times are the same. From position T, the observed time is 19 min later than the calculated time.

3. Given that the diameter of the Earth's orbit is 3.0×10^{11} m, the speed of light as measured by the amateur astronomers is

A. 1.6×10^{8} m/s
B. 2.6×10^{8} m/s
C. 3.0×10^{8} m/s
D. 1.6×10^{10} m/s

Use the following information to answer question 4.

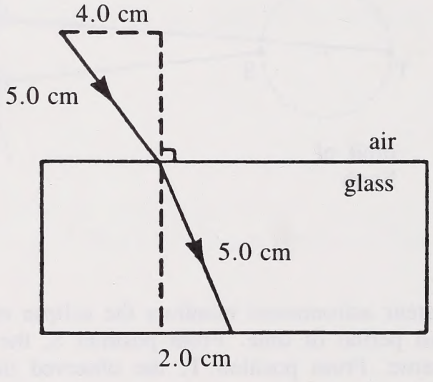


Two plane mirrors XY and YZ are at right angles to each other.

4. A ray of light strikes mirror XY 5.0 cm from Y. At what distance from Y will the reflected ray strike mirror YZ?

A. 3.2 cm
B. 3.8 cm
C. 4.2 cm
D. 6.0 cm

Use the following information to answer question 5.



A ray of light travels from air into glass.

5. The speed of light in the glass is

A. 1.5×10^8 m/s
B. 2.0×10^8 m/s
C. 2.3×10^8 m/s
D. 2.6×10^8 m/s

---

6. In a particular medium, light with a frequency of 5.0×10^{14} Hz travels 10.0 m in 4.0×10^{-8} s. Its wavelength is

A. 4.2×10^{-7} m
B. 5.0×10^{-7} m
C. 6.0×10^{-7} m
D. 2.0×10^{-6} m

7. In comparing the wavelength, frequency, and speed of light in air to the same quantities in glass, one would find that

A. frequency, wavelength, and speed all differ
B. frequency is the same, but wavelength and speed differ
C. speed is the same, but wavelength and frequency differ
D. wavelength is the same, but frequency and speed differ

8. The work that Römer did is important because it

A. established that the speed of light is constant
B. measured the speed of light to be 3.0×10^{8} m/s
C. led to the calculation of a finite value for the speed of light
D. established that the speed of light varies in relation to its frequency

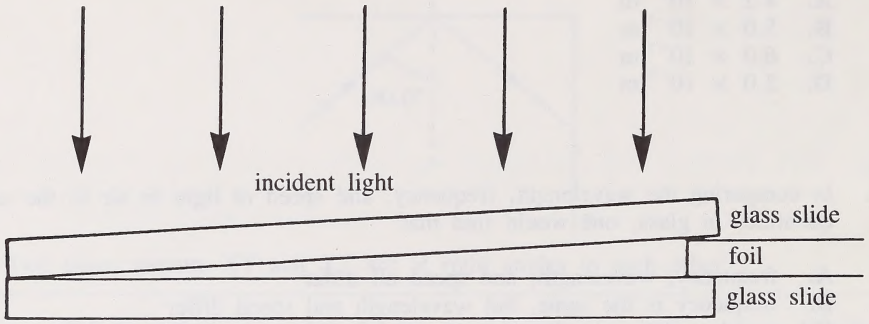
9. Light passes through glass that has a refractive index of 1.50 and then enters a second medium that has a refractive index of 1.75. The speed of light in the second medium is

A. 1.71×10^{8} m/s
B. 2.00×10^{8} m/s
C. 2.57×10^{8} m/s
D. 3.50×10^{8} m/s

10. In glass ($n = 1.50$), a certain infra-red source has a wavelength of 8.00×10^{-7} m. Its frequency is

A. 8.44×10^{14} Hz
B. 5.63×10^{14} Hz
C. 3.75×10^{14} Hz
D. 2.50×10^{14} Hz

Use the following information to answer question 11.



An experiment is set up with two pieces of flat glass placed so that they are in contact along one edge and separated by a piece of foil at the other edge. When monochromatic light shines on to the slides from above, dark and bright lines appear on the glass.

11. The dark and bright lines are caused by

A. scattering
B. dispersion
C. diffraction
D. interference

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12. Light illuminates two slits that are 0.10 cm apart and forms a diffraction pattern on a screen 12.0 m from the slits. If the first order image is formed 6.0 mm from the bright central band, what is the wavelength of the incident light?

A. 7.2×10^{-1} m
B. 2.0×10^{-2} m
C. 5.0×10^{-4} m
D. 5.0×10^{-7} m

13. White light can be dispersed into its component colors because

A. the speed of light is independent of wavelength
B. long wavelengths refract less than short wavelengths
C. long wavelengths diffract more than short wavelengths
D. long wavelengths do not travel as fast as short wavelengths

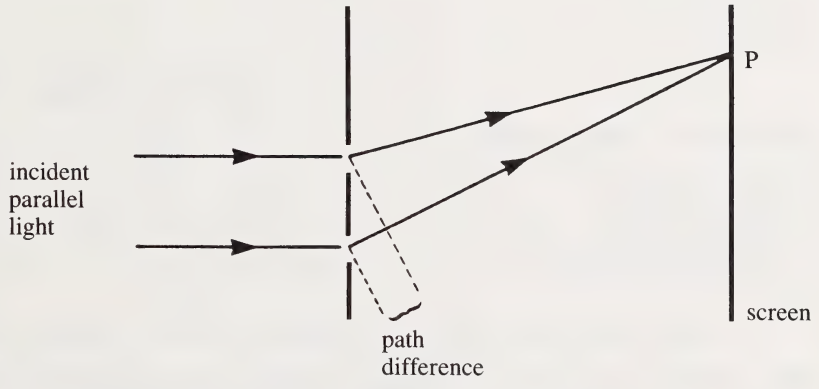
14. A small, opaque, solid disk that is placed in a beam of light casts a shadow with a bright central spot. This phenomenon can be explained by the concepts of

A. diffraction and reflection
B. refraction and polarization
C. interference and refraction
D. interference and diffraction

15. Newton assumed that all wave motion is longitudinal. Because of this assumption, he could not accept the wave theory of light with respect to

A. reflection
B. refraction
C. propagation
D. polarization

Use the following information to answer question 16.

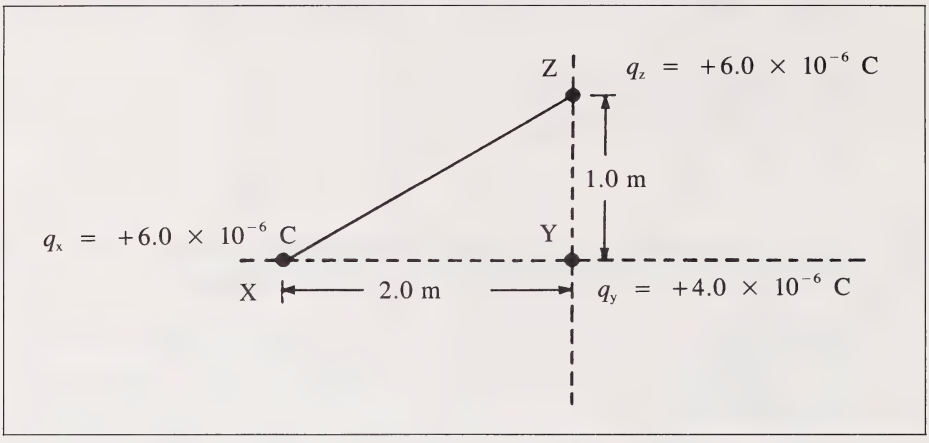


Parallel light waves of a single wavelength are incident on two narrow slits and produce an interference pattern on the screen.

16. There will be a bright fringe at P when the path difference is

A. 0.5λ
B. 1.5λ
C. 2.0λ
D. 3.5λ

Use the following information to answer question 17.



17. The magnitude of the force acting on Y due to X and Z is

A. 0.76 N
B. 0.22 N
C. 0.032 N
D. 0.027 N

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18. The coulomb is defined as one

A. ampere-second
B. volt per second
C. electronic charge
D. ampere per second

19. When a helium nucleus with a charge of $+2e$ and a neon nucleus with a charge of $+10e$ are separated by 3.0×10^{-8} m, the force of repulsion is

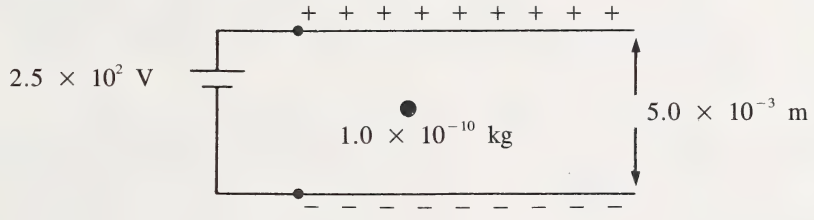
A. 5.1×10^{-12} N
B. 3.2×10^{7} N
C. 6.0×10^{18} N
D. 2.0×10^{26} N

20. An example of a scalar field is

A. gravity
B. magnetism
C. temperature
D. wind velocity

Use the following information to answer question 21.

The charged particle has a mass of 1.0×10^{-10} kg and is suspended in an electric field between two horizontal plates that are 5.0×10^{-3} m apart. The potential difference between the plates is 2.5×10^{2} V.



21. The magnitude of the charge is

A. 2.0×10^{-14} C
B. 9.8×10^{-10} C
C. 1.2×10^{-9} C
D. 3.9×10^{-8} C

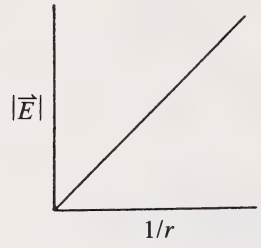
---

22. The direction of the electric field near a positively-charged particle is

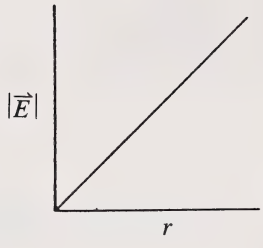
A. counter-clockwise around the charge
B. clockwise around the charge
C. inward toward the particle
D. outward from the particle

23. Which graph represents the electric field strength $|\vec{E}|$ as a function of the distance r from a point charge?

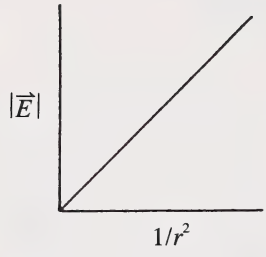
A.



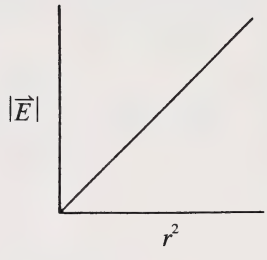
B.



C.



D.



24. The total kinetic energy acquired by 5.0×10^{19} electrons when they are accelerated from rest by a potential difference of 32 V is

A. 2.6×10^{2} J
B. 4.0×10^{2} J
C. 6.4×10^{6} J
D. 1.6×10^{21} J

25. A television set draws 2.00 A from a 117 V line. The energy used by the set during 48.0 h of operation is

A. 2.34×10^{2} J
B. 1.12×10^{4} J
C. 3.46×10^{5} J
D. 4.04×10^{7} J

26. An electrical circuit being supplied by a 12 V battery carries a current of 3.0 A. The number of electrons passing a given point in the circuit in each 2.0 s period is

A. 1.5×10^{19}
B. 2.5×10^{19}
C. 3.8×10^{19}
D. 9.6×10^{19}

27. The voltaic cell was important to the development of experimental work in electricity because it

A. substantiated Faraday's theories
B. substantiated the existence of ions
C. provided a source of continuous direct current
D. allowed comparison of the theories of electricity and magnetism

28. Which of the following are units of power?

A. J and $A \bullet \Omega$
B. J and V^2/Ω
C. $A \bullet \Omega$ and $A^2 \bullet \Omega$
D. $A^2 \bullet \Omega$ and V^2/Ω

29. A 0.20 g mass with a charge of 2.0 C enters a magnetic field of strength 2.0×10^{-4} T with a velocity of 3.0×10^{6} m/s perpendicular to the field. The path of the particle has a radius of

A. 0.12 m
B. 1.2 m
C. 1.5×10^{6} m
D. 1.5×10^{12} m

30. If an electron that travels through a magnetic field at 4.5×10^{6} m/s experiences a deflecting force of 3.2×10^{-13} N, what is the strength of the magnetic field?

A. 2.3 T
B. 0.44 T
C. 7.1×10^{-3} T
D. 1.4×10^{-6} T

31. The charged particles in the Van Allen radiation belts most probably have been trapped there by

A. an electric field
B. a magnetic field
C. a scalar light field
D. a gravitational field

Use the following information to answer question 32.

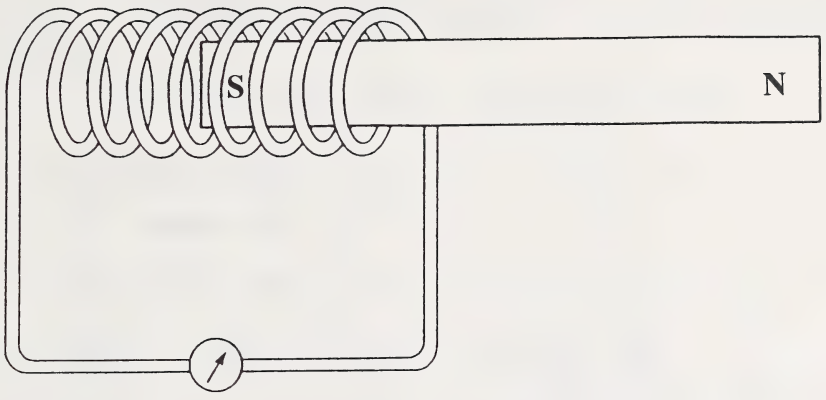
A student proposed the following list of possible properties of electromagnetic radiation:

I Electromagnetic radiation travels at the speed of light in free space.
II Electromagnetic radiation has a fixed frequency and wavelength.
III Electromagnetic radiation propagates through the creation of mutually perpendicular electric and magnetic fields.
IV Electromagnetic radiation has constant electric and magnetic fields which do not vary with time.

32. Which are properties of ALL forms of electromagnetic radiation?

A. I only
B. I and II
C. I and III
D. I and IV

Use the following information to answer question 33.



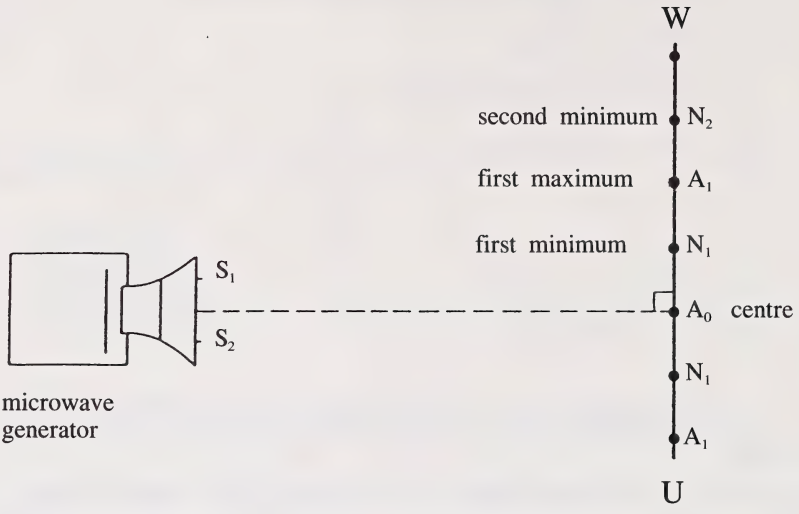
In an experiment, a coil is connected to a sensitive ammeter as shown. When a magnet is moved toward the right, the pointer on the ammeter moves to the right.

33. Which operation can also be predicted to result in the pointer moving to the right?

A. Spin the magnet
B. Move the coil toward the left
C. Move the coil toward the right
D. Move the magnet toward the left

Use the following information to answer question 34.

Microwave Double-Slit Experiment



A two-source extension is placed over the horn of a microwave generator that transmits radiation with a frequency of 5.0×10^{10} Hz. This procedure converts the generator into a double-slit apparatus. A detector moves along line UW. This diagram is NOT drawn to scale.

34. If S_1 and S_2 are separated by 0.20 m and A_1 is 0.30 m from A_0, the distance from the horn to A_0 is

A. 5.0 m
B. 6.0 m
C. 10 m
D. 15 m

---

35. One measured quantity that remains the same regardless of the observer's frame of reference is the

A. speed of light
B. mass of an object
C. wavelength of light
D. weight of an object

Use the following data to answer question 36.

X-rays are produced when a metal target is bombarded by a stream of electrons. The table shows the wavelength of X-rays produced as a function of accelerating voltage.

Accelerating Voltage (10^5 V)	Wavelength (10^{-12} m)
1.8	4.6
2.0	4.4
3.5	2.5
4.5	1.9

From the data above, the following inferences may be drawn.

I Wavelength is directly proportional to accelerating voltage.
II Wavelength is inversely proportional to accelerating voltage.
III Frequency is directly proportional to accelerating voltage.
IV Frequency is inversely proportional to accelerating voltage.

36. The inferences that are consistent with the data are

A. I and III
B. I and IV
C. II and III
D. II and IV

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37. After conducting their experiment on the ether wind, Michelson and Morley concluded that

A. there was no ether wind observable in their experiment
B. an interference pattern was produced by the different mirrors
C. the speed of light is less when travelling against the ether wind
D. the speed of light is greater when travelling with the ether wind

38. Infra-red radiation is primarily associated with

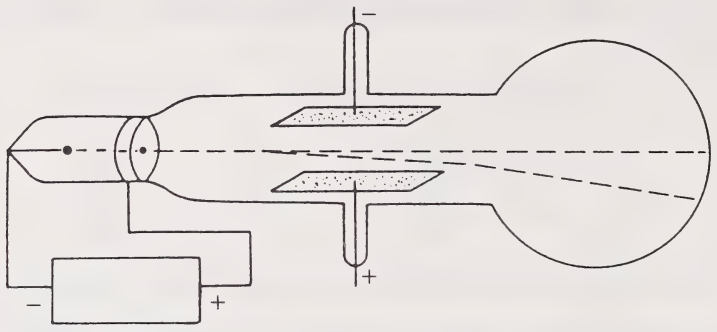
A. heated objects
B. microwave ovens
C. suntanning equipment
D. radioactive substances

39. Mendeleev's work in grouping elements into a periodic table led him to predict accurately the

A. relative volumes of atoms
B. number of valence electrons of each element
C. atomic masses of all the elements known at that time
D. chemical properties of many elements that were unknown at the time

Use the following information to answer questions 40 to 42.

Cathode Ray Tube



Potential difference across deflector plates = 601 V
Deflector plate separation = 4.0 cm
Deflector plate length = 10.0 cm
Speed of cathode-ray particle = $0.017c$

40. The particles are between the deflector plates for a time of

A. 8.0×10^{-9} s
B. 2.0×10^{-8} s
C. 3.3×10^{-7} s
D. 2.0×10^{-6} s

41. The magnitude of the electric field between the deflector plates is

A. 1.5×10^{2} N/C
B. 6.0×10^{3} N/C
C. 1.5×10^{4} N/C
D. 3.7×10^{21} N/C

42. When a cathode-ray particle is between the deflector plates, its vertical acceleration is approximately

A. 3.0×10^{8} m/s^2
B. 1.4×10^{9} m/s^2
C. 1.4×10^{12} m/s^2
D. 2.6×10^{15} m/s^2

43. The photoelectric effect was instrumental in the development of our present understanding of the physical world because it

A. supported the wave theory of light
B. demonstrated that light can behave like particles
C. supported the theory of the equivalence of mass and energy
D. demonstrated the existence of positive particles called photoelectrons

44. The frequency of the light that forms the third line of the Balmer series ($n_f = 2$) of hydrogen is

A. 6.9×10^{14} Hz
B. 4.6×10^{14} Hz
C. 2.3×10^{6} Hz
D. 4.3×10^{-7} Hz

45. The Rutherford-Bohr theory is unable to explain the

A. size of the hydrogen atom
B. emission and absorption spectra of hydrogen
C. splitting of spectral lines by a magnetic field
D. results of alpha particle scattering experiments

46. Results of a Rutherford-type scattering experiment can be used to determine the

A. size of a nucleus
B. mass of a nucleus
C. wave properties of alpha particles
D. particle properties of alpha waves

47. The de Broglie wavelength of a 5.0×10^{-26} kg mass that moves at a speed of 2.0×10^{6} m/s is

A. 1.0×10^{24} m
B. 1.3×10^{-8} m
C. 6.6×10^{-15} m
D. 1.0×10^{-19} m

48. A proton is given sufficient energy to reach a speed of 2.25×10^{8} m/s. At this speed, the proton would have a mass of

A. 1.38×10^{-30} kg
B. 8.60×10^{-28} kg
C. 1.67×10^{-27} kg
D. 2.53×10^{-27} kg

49. The equivalent mass of a photon of light with a frequency of 5.00×10^{14} Hz is

A. 3.68×10^{-36} kg
B. 1.10×10^{-26} kg
C. 9.95×10^{-10} kg
D. 5.50×10^{-2} kg

50. The BEST description of the Compton effect is that

A. photons transfer momentum to electrons
B. electrons strike metal atoms and produce photons
C. electrons exist as standing waves around the nucleus
D. alpha particles strike gold foil and pass through unaffected

51. What postulate is needed to derive the equation $mrv = \frac{nh}{2\pi}$?

A. Orbits contain a whole number of electron waves.
B. Stationary states involve no emission or absorption.
C. Angular momentum is not conserved in a Bohr orbit.
D. Electrons are held to the nucleus by a Coulomb force.

52. The model that provides an initial mathematical description of the atom but does not provide an immediate physical description of it is the

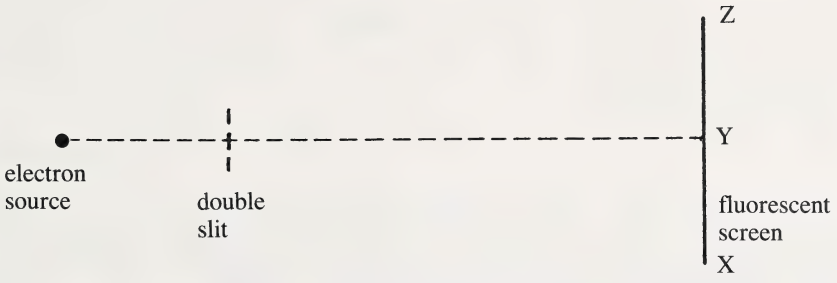
A. Bohr model
B. Thomson model
C. Rutherford model
D. quantum mechanical model

53. "We are unable to measure simultaneously both the position and velocity of an electron to unlimited accuracy." This concept was proposed by

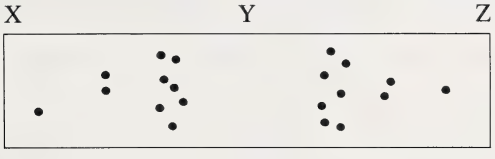
A. Compton
B. de Broglie
C. Heisenberg
D. Schrödinger

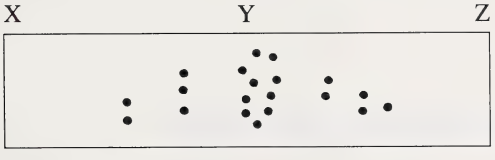
Use the following information to answer question 54.

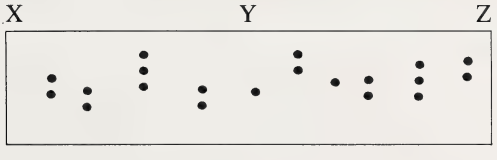
A beam of electrons is directed at two, narrow, closely spaced slits. Each electron that passes through a slit causes a tiny flash of light on a fluorescent screen. After many electrons have passed through the slits, the distribution of flashes on the screen shows a double-slit interference pattern of bright and dark lines.

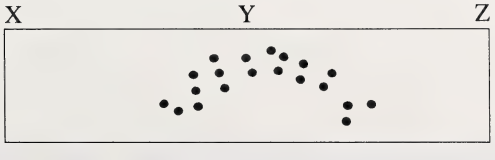


54. A probable distribution of flashes on the screen after the first 20 electrons have passed through the slits could be represented by

A.


B.


C.


D.


Use the following information to answer question 55.

In an experiment similar to the Compton effect experiment, X-ray photons of energy 1.0×10^5 eV strike target electrons. Each electron gains 4.0×10^4 eV of kinetic energy and X-ray photons are scattered. The collision is one dimensional and perfectly elastic.

55. The frequency of a scattered photon is

A. 1.0×10^{19} Hz
B. 1.4×10^{19} Hz
C. 2.4×10^{19} Hz
D. 3.4×10^{19} Hz

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56. To accurately locate an atomic particle using electromagnetic radiation, the radiation

A. frequency must be lower than that of the particle
B. frequency must be higher than that of the particle
C. wavelength must be larger than the size of the particle
D. wavelength must be smaller than the size of the particle

YOU HAVE NOW COMPLETED THE MULTIPLE-CHOICE SECTION OF THE EXAMINATION. PLEASE PROCEED TO THE NEXT PAGE AND ANSWER THE WRITTEN-RESPONSE QUESTIONS IN PART B.

PART B

INSTRUCTIONS

Please write your answers in the examination booklet as neatly as possible.

Marks will be awarded for pertinent explanations, calculations, formulas, and answers. Answers must be given to the appropriate number of significant digits.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

TOTAL MARKS: 14

START PART B IMMEDIATELY

FOR DEPARTMENT USE ONLY

1. In a mass spectrometer, alpha particles with a non-relativistic kinetic energy of 9.00×10^4 eV are injected at right angles to a magnetic field B.

(2 marks)

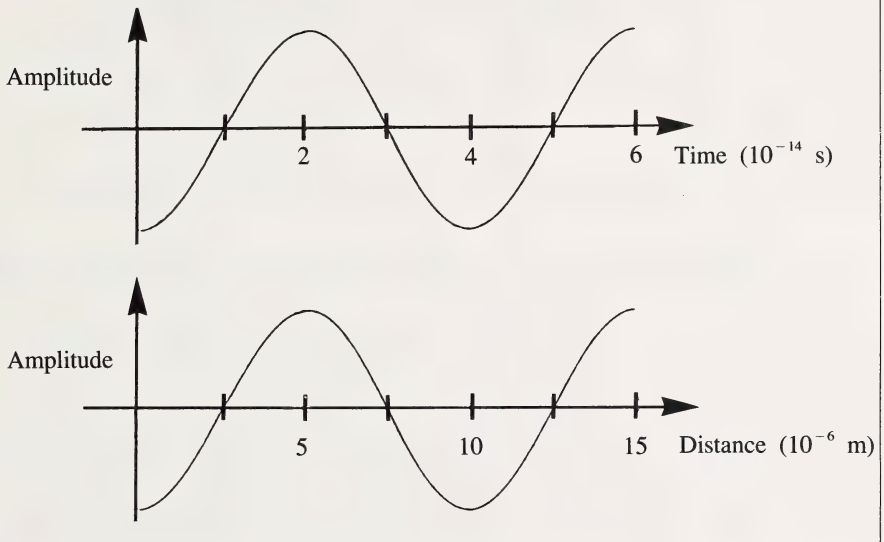
a. Find the speed of the alpha particles.

(2 marks)

b. Find the strength of the magnetic field required to keep the alpha particles moving in a circle of radius 6.03 m. (If you were unable to calculate an answer for part a., use the hypothetical value $v = 1.85 \times 10^6$ m/s.)

Use the following equation to answer question 2.

The following graphs show the amplitude of the electric field of an electromagnetic wave in a particular medium. The first shows the amplitude and time at a particular location; the second shows the amplitude and position at a particular instant.



2. From the graphs, determine the speed of the electromagnetic wave and the refractive index of the medium. Express both answers to two significant digits. **(4 marks)**

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Use the following information to answer question 3.

In an investigation of the photoelectric effect, a student determined the stopping voltage for various frequencies of incident light. The results are summarized below.

Trial	Frequency (10^{14} Hz)	Stopping Voltage (V)
1	5.0	1.0
2	6.0	1.3
3	7.0	1.8
4	8.0	1.9
5	9.0	2.3

(2 marks)

3. a. Construct a graph using the above data, with axes appropriately labelled.

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b. From the graph, determine the experimental values for Planck's constant and the threshold frequency. **(3 marks)**

c. Calculate the percentage error in the experimental value of Planck's constant. **(1 mark)**

YOU HAVE NOW COMPLETED THE EXAMINATION. IF YOU HAVE TIME, YOU MAY WISH TO GO BACK AND CHECK YOUR ANSWERS.

TEAR-OUT SHEET

(NO MARKS WILL BE GIVEN FOR WORK DONE ON THIS PAGE)

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M1 M2 M3 M4

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PHYSICS 30

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PHYSICS 30